Corrosion Control

Part 192, Subpart I

- External
- Internal
- Atmospheric

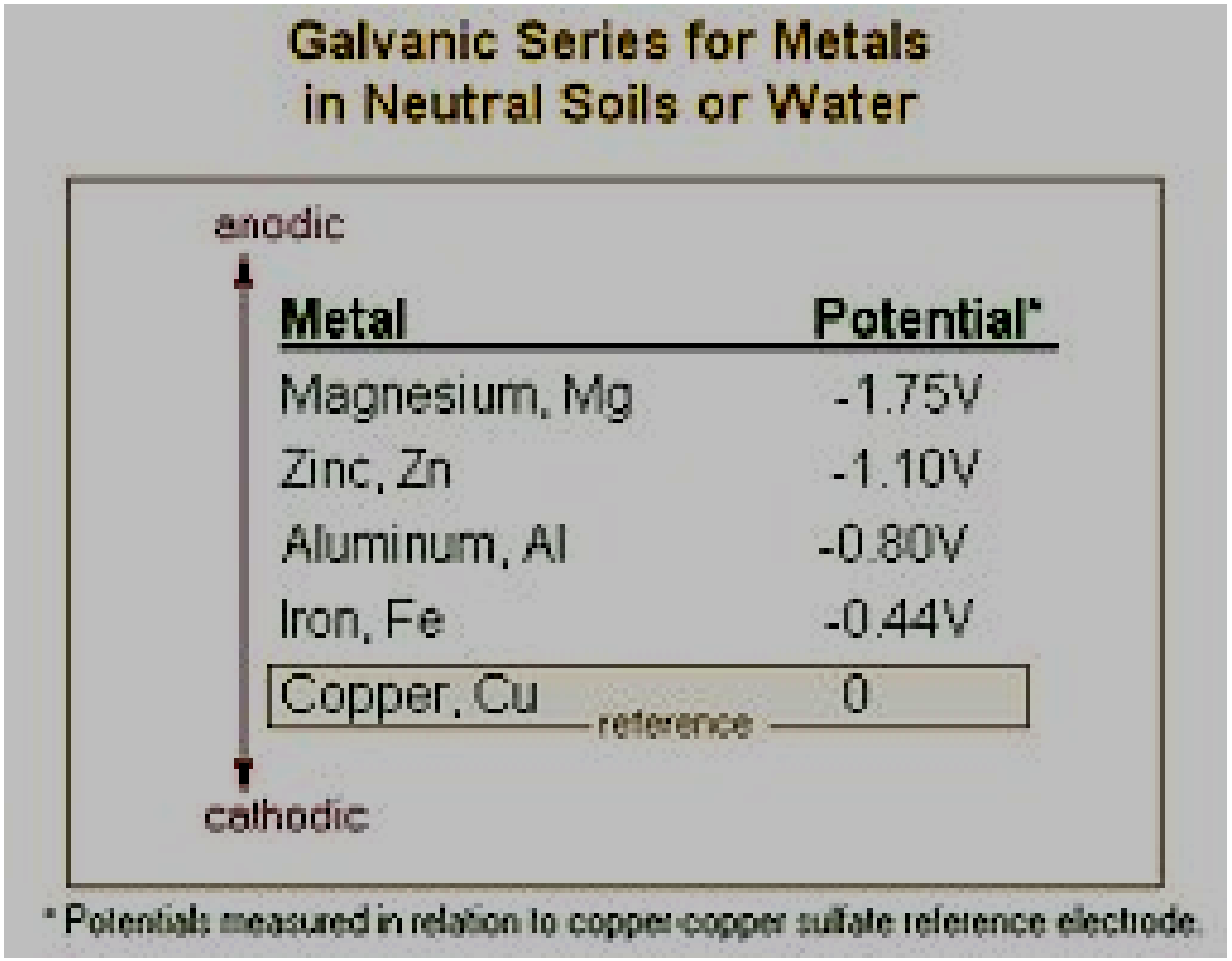
Subpart I Added To Part 192 By Amendment 4, 8/1/71

Definition of Corrosion

- **The Deterioration of a Material, Usually a Metal, that Results from a Reaction with its Environment.**

- **Galvanic Corrosion of a Metal Occurs because of an Electrical Contact with a More Noble (Positive) Metal or Non-metallic Conductor in a Corrosive Electrolyte.**

Galvanic Series of Metals



Basic Corrosion Cell

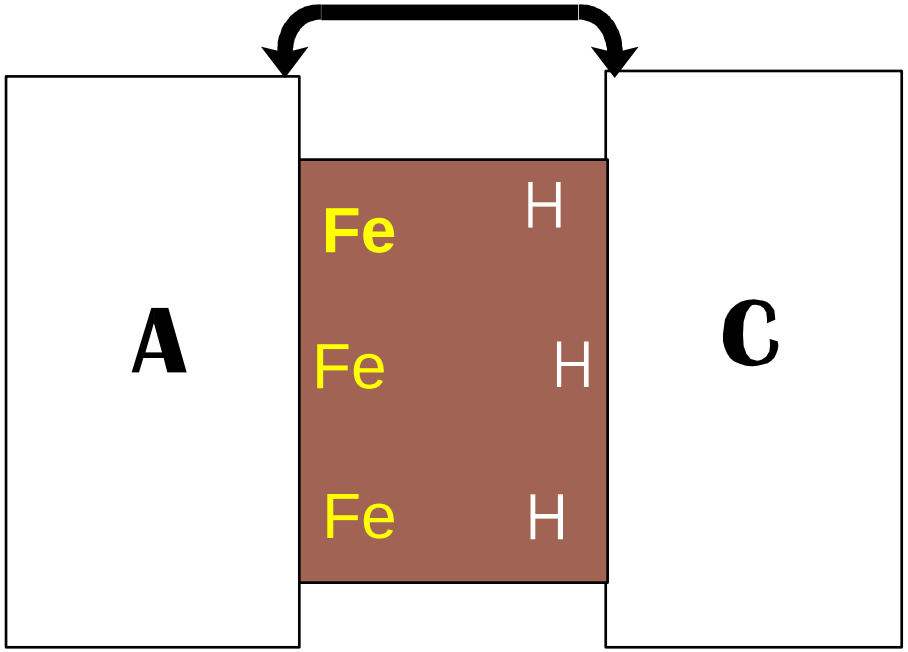
Metallic Path

ANODE

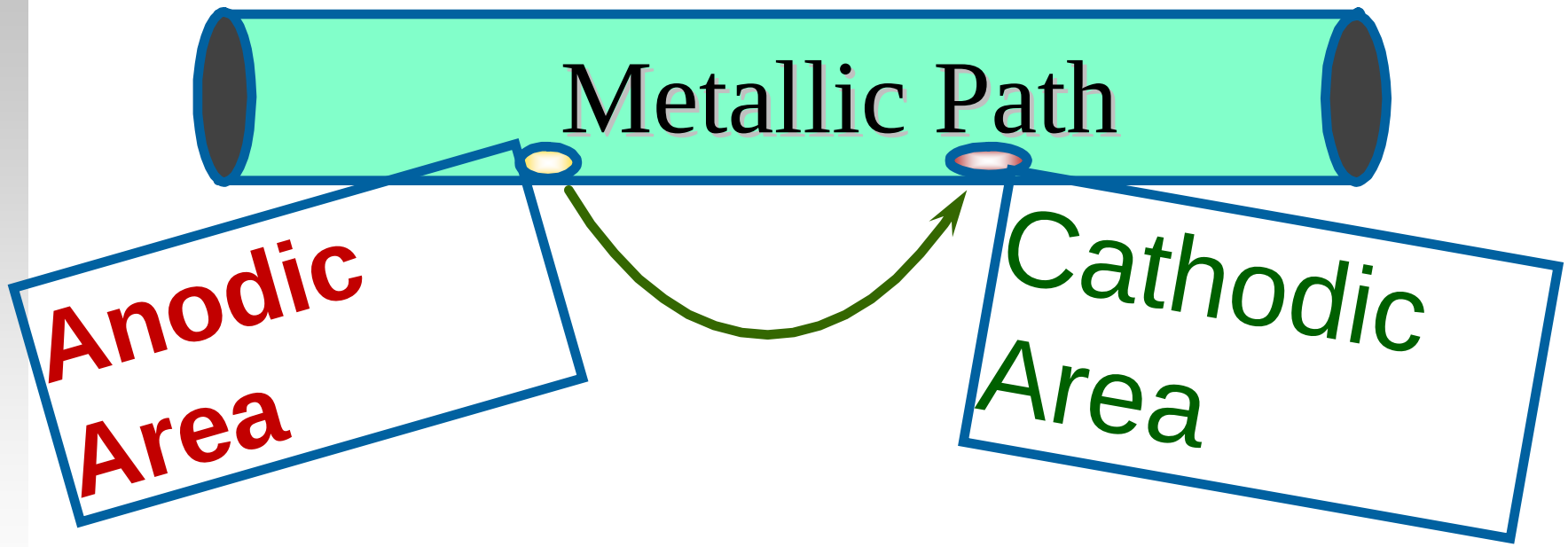
CATHODE

ELECTROLYTE

METALLIC PATH



Pipe Corrosion



Corrosion on Pipelines

- Dissimilar Metals
- Dissimilar Soils
- Differential Aeration
- Mill Scale Corrosion

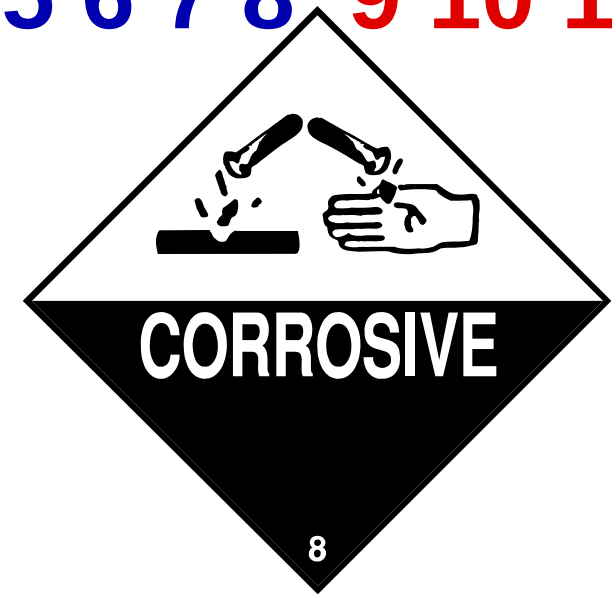
Soil Resistivity vs. Corrosivity

Ohm - cm	Description
Below 500	very
500 - 1000	corrosive
1000 - 2000	moderately corrosive
2000 - 10,000	mildly
> 10,000	<< corrosive

SOIL pH

ACIDIC **ALKALINE**

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14

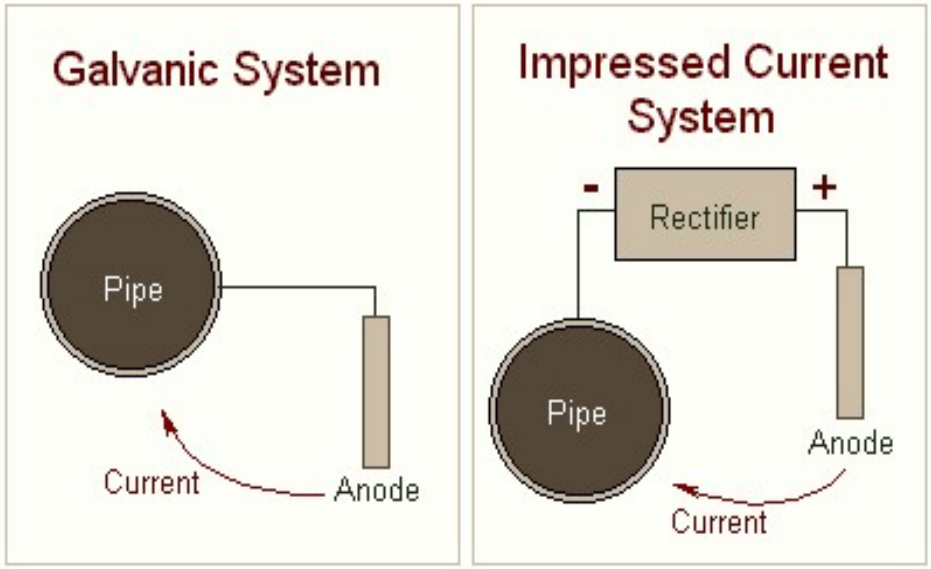


Cathodic Protection

- The Decrease of Corrosion of a Metal by Forcing Current to Flow to the Metal from a Solution (Electrolyte).

Cathodic Protection

- Galvanic Sacrificial Anodes
- Impressed Current Systems



* Properly Designed & Installed

Qualified Person §192.453

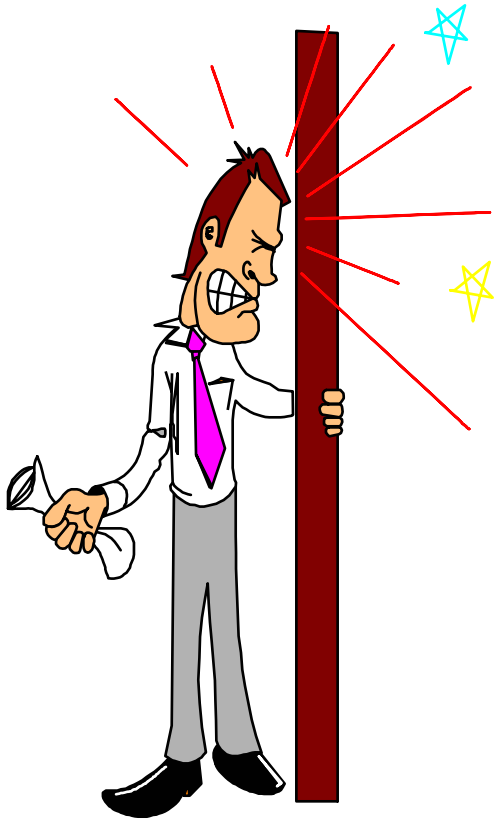
- Must be carried out by, or under the direction of, a person qualified in pipeline corrosion control methods.

Qualified Person

- **Operator Qualification requires that an unqualified person must be under the <u>direct observation</u> of a qualified person.**

Required System Information

- Date of Installation
- Transmission or Distribution
- Coated or Bare



Requires CP

- Coated Metallic Pipelines Installed after 7/31/71 (§192.455(a))
- Coated Transmission Lines (except station piping) Installed prior to 8/1/71 (§192.457(a))

Requires CP

- **Areas of Active Corrosion - Installed < 8/1/71 (§192.457(b))**
  - **Bare or Ineffectively Coated Transmission Lines**
  - **Station Piping (Bare or Coated)**
  - **Bare or Coated Distribution Lines**

CP Not Required

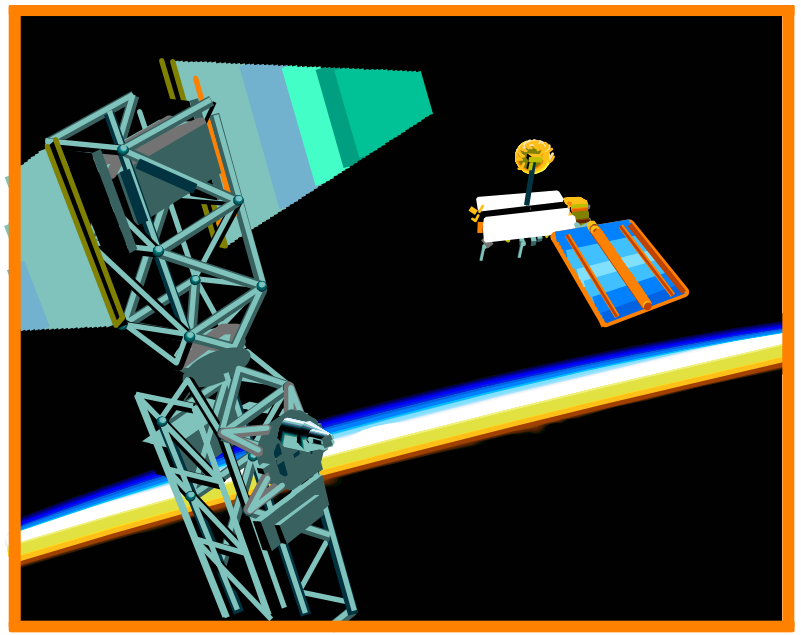
- **Bare TEMPORARY lines installed after 7/31/71 (§192.455(c)(2)&(d)).**

- **Bare or ineffectively coated lines installed prior to 7/31/71 with no evidence of active corrosion (§192.457(b)).**

CP Not Required (cont.)

- Electrically isolated metal alloy fittings in plastic pipeline systems (§192.455(f)).

- Pipelines in NON-CORROSIVE environments (§192.455(b)).



NON-CORROSIVE ENVIRONMENT

Tests Needed to Demonstrate:

- Soil Resistivity Measurements
- Corrosion Accelerating Bacteria
- Leak Frequency
- Soil Composition
- pH
- Bell Hole Examinations
- Internal Inspections

- *POST-INSTALLATION TESTS* **(< 6 *MONTHS*)**
  - * Close Interval Potential
  - * Soil Resistivity

CATHODIC PROTECTION

- §192.463 Requires Cathodic Protection to a Level that Complies with Appendix D.

CATHODIC PROTECTION CRITERIA

- 850 mv
- 100 mv Polarization Decay
- Negative 300 mv Shift
- Net Protective Current
- E log I (Gas)

Components of IR Drop

Resistances

Measuring Lead (+)
Contact Lead (+)/Ref. Cell
Reference Cell
Contact Ref. Cell/Electrolyte
Electrolyte
Polarization
Structure
Contact Test Lead/Structure
Test Lead
Contact Test/Measuring Lead
Measuring Lead (-)
Internal Meter

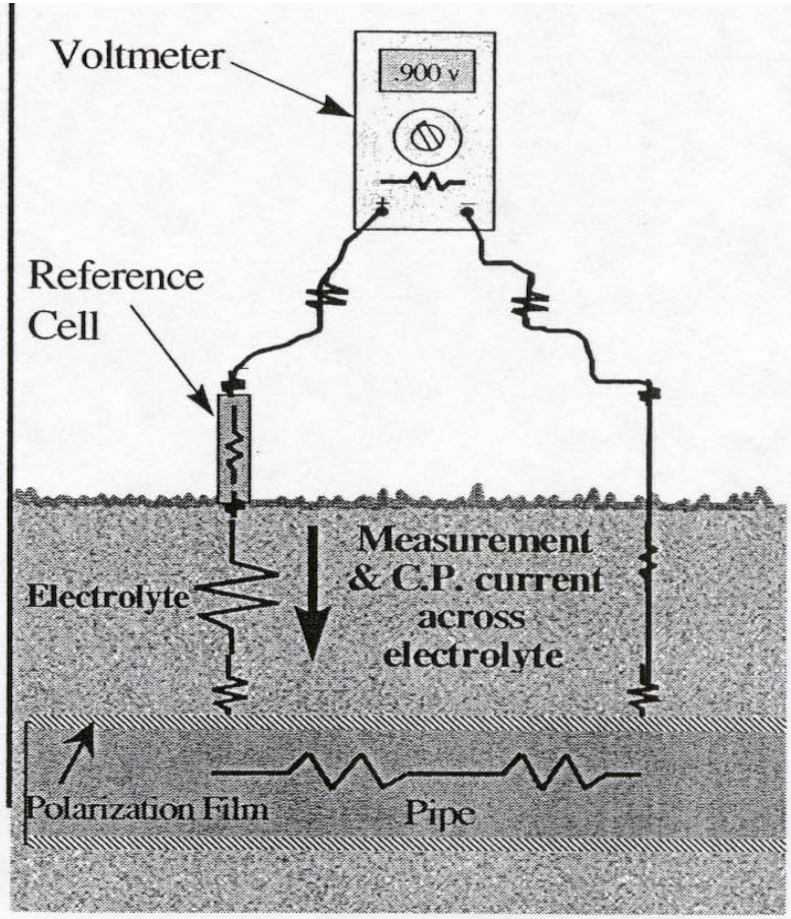


Figure 3.9 Voltage Drops in a Measuring Circuit

IR Drop ~ Major Contributors

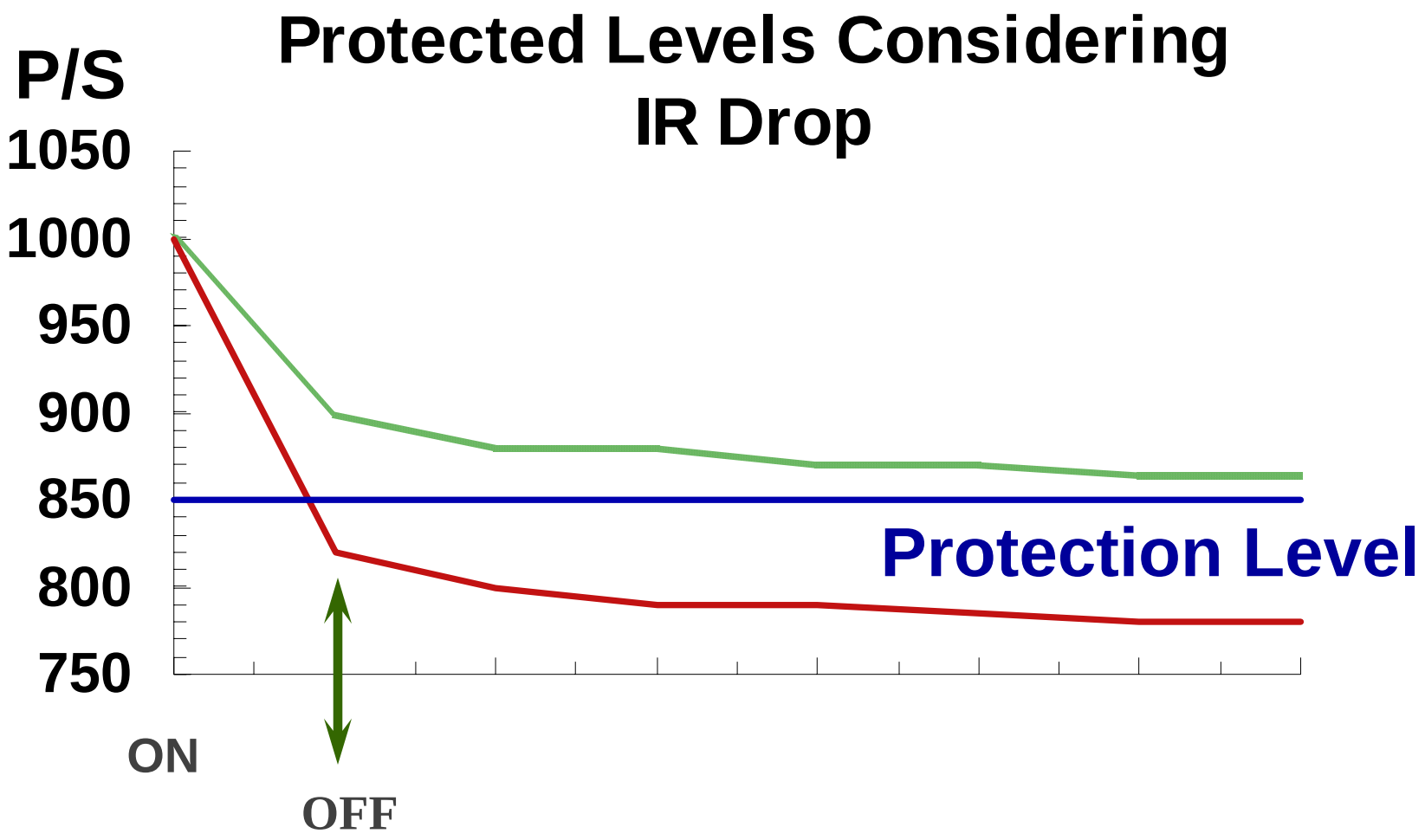
- Contact between the reference cell and the soil.
- Electrolyte (soil)
- Polarization at the pipe coating / soil interface

C. P. CRITERIA (850 mv)

- 850 mv.
- Measured with Current Applied
- Consider IR Drop
- Cu/$CuSO_4$ Reference Electrode

- 800 mv. Ag/Ag Cl for sea water

C. P. CRITERIA (850 mv)

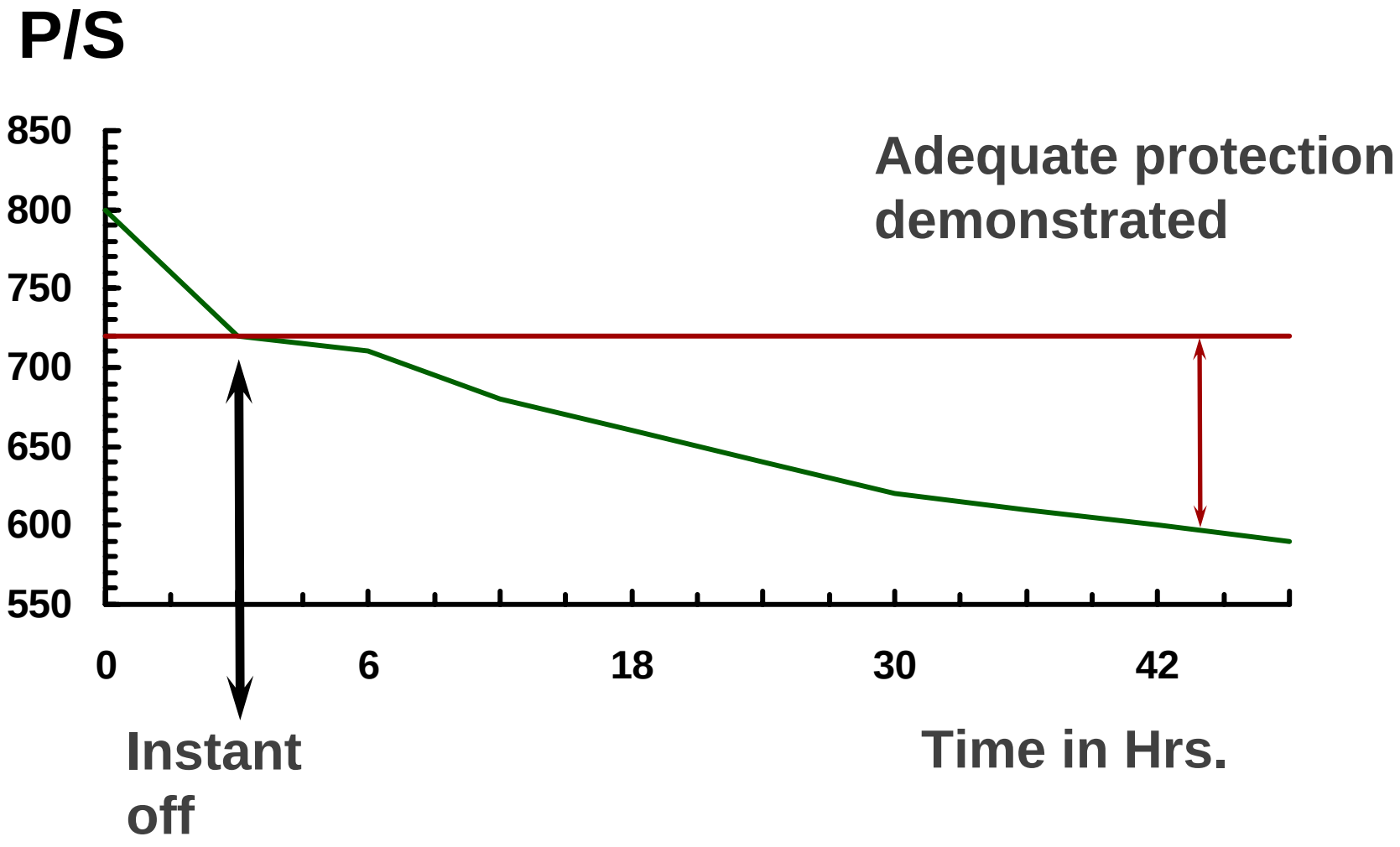


Cathodic Protection Criteria

100 mv. Polarization Decay

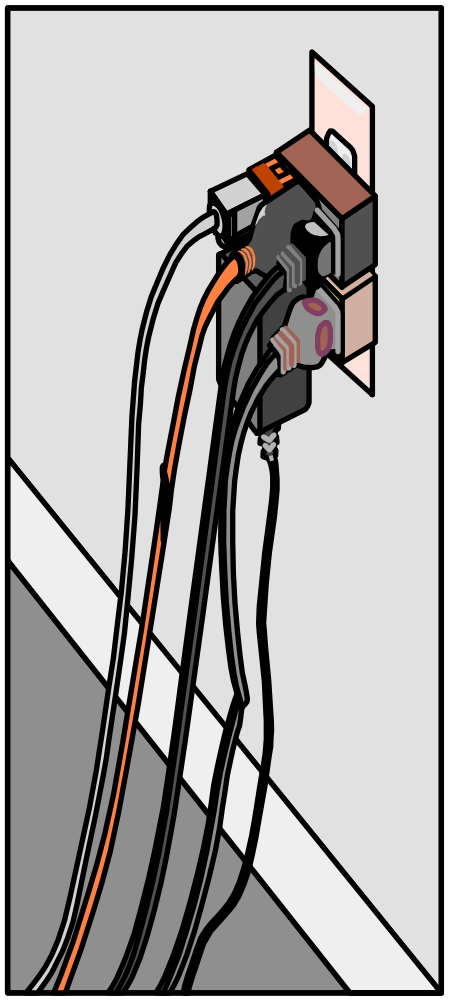
- Current Interruption
- Cu/$CuSO_4$ Reference

100 MV Polarization Decay

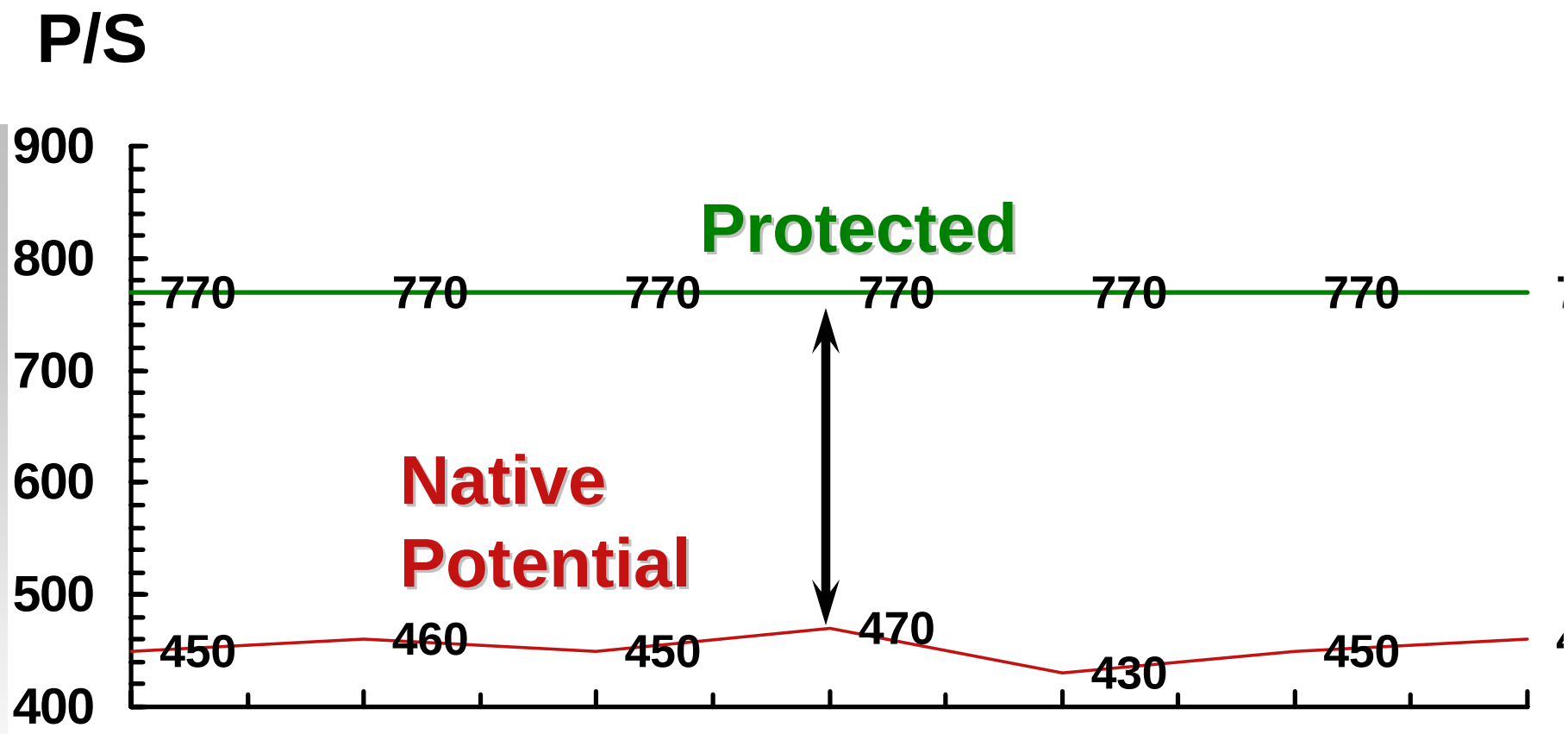


C. P. Criteria (-300 mv Shift)

- Measured with Current Applied
- Consider IR Drop
- $Cu/CuSO_4$ Reference
- Does NOT Apply to Structures with Different Anodic Potentials



300 mv Shift


P/S
900
800
700
600
500
400
Protected
770
770
770
770
770
770
Native
Potential
450
460
450
470
430
450

Cathodic Protection Criteria

Net Protective Current

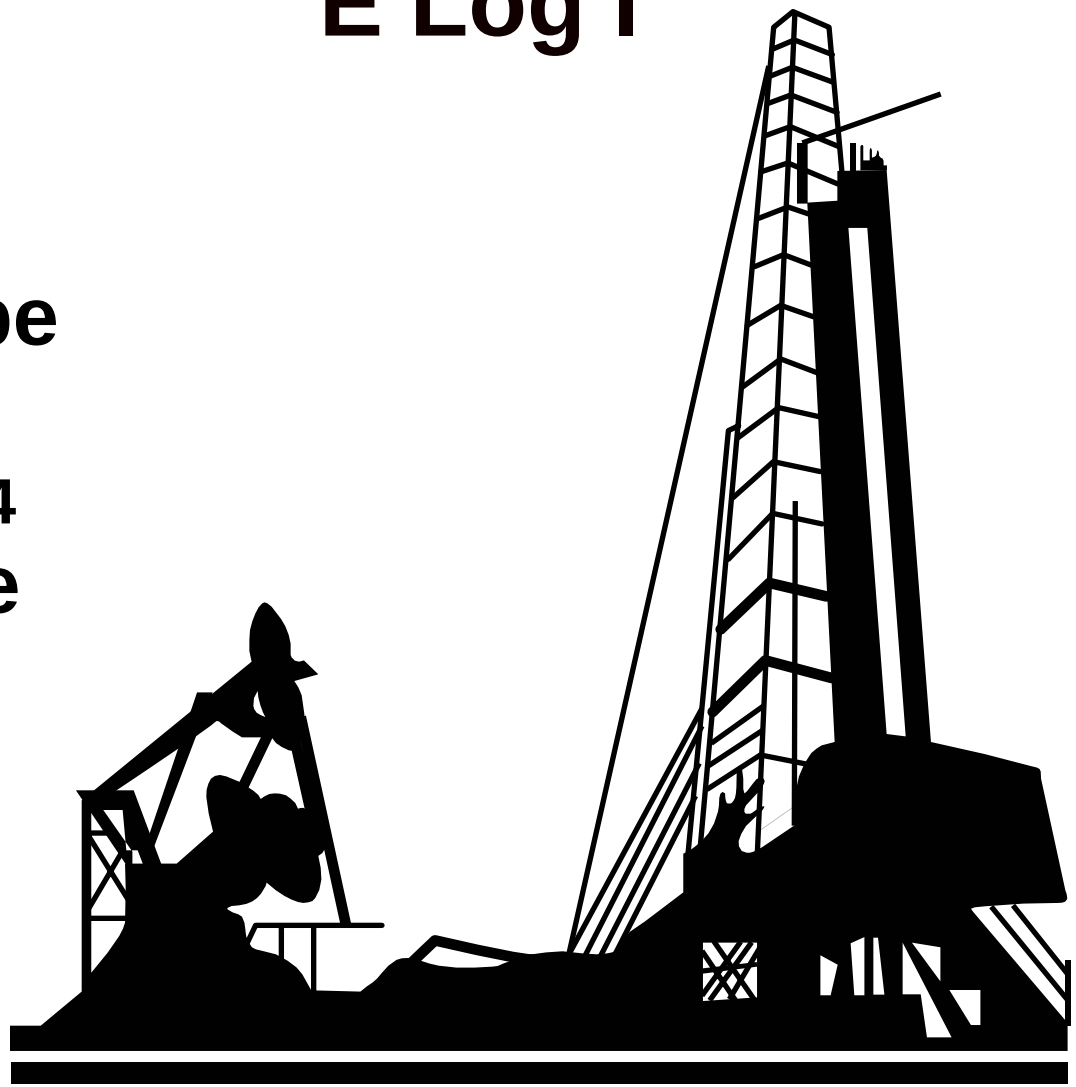
- Current Flow from Electrolyte to Structure

- At Predetermined Anodic Areas

Cathodic Protection Criteria

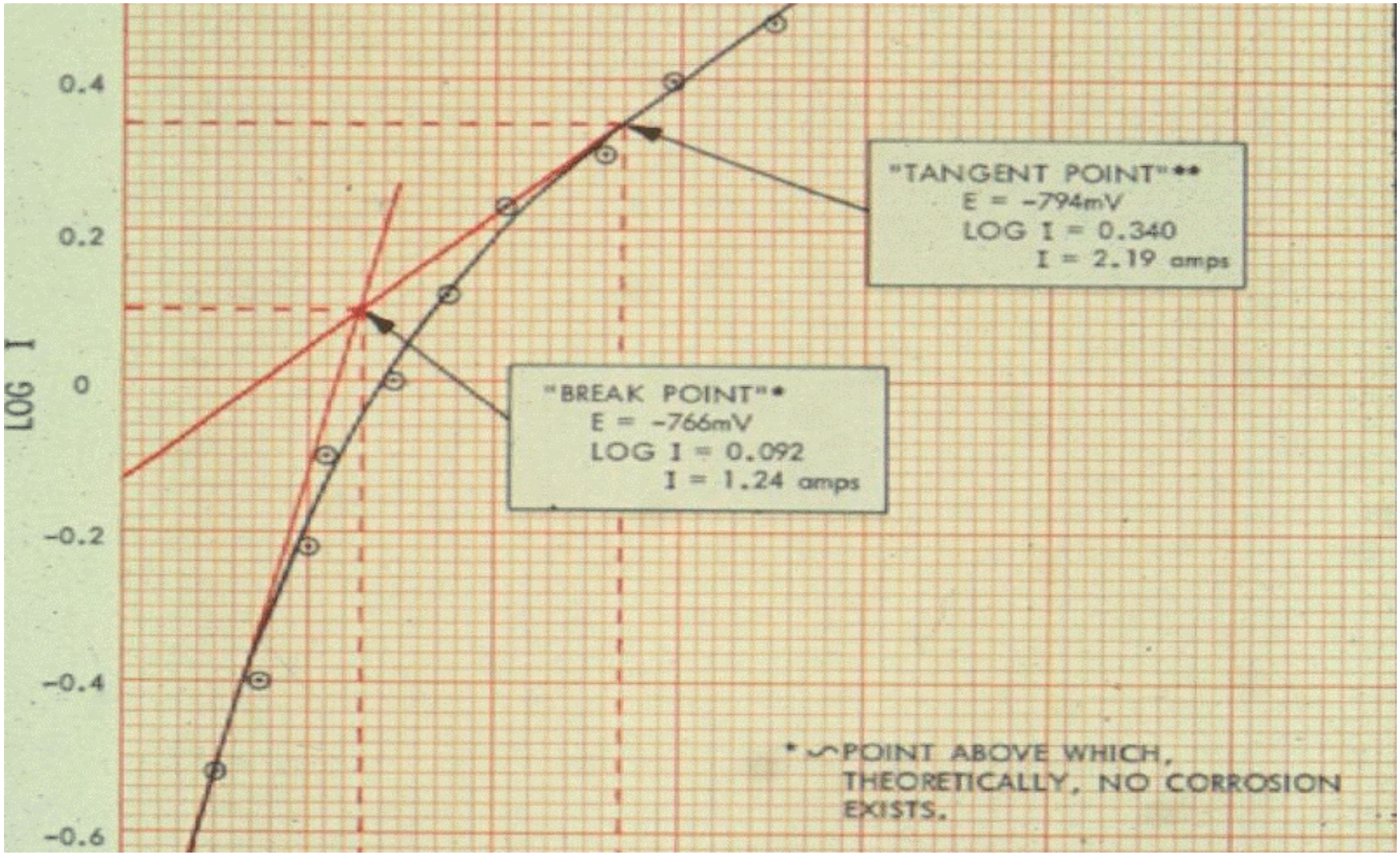
E Log I

- Tafel Slope
- $Cu/CuSO_4$ Reference



Cathodic Protection Criteria

E Log I



Monitoring §192.465(a)&(c)

- Cathodically Protected Zones
- Isolated Sections
  < 100 ft. (Gas Mains or Transmission)
  10% Sampling Per Yr.
- Non-Critical Bonds

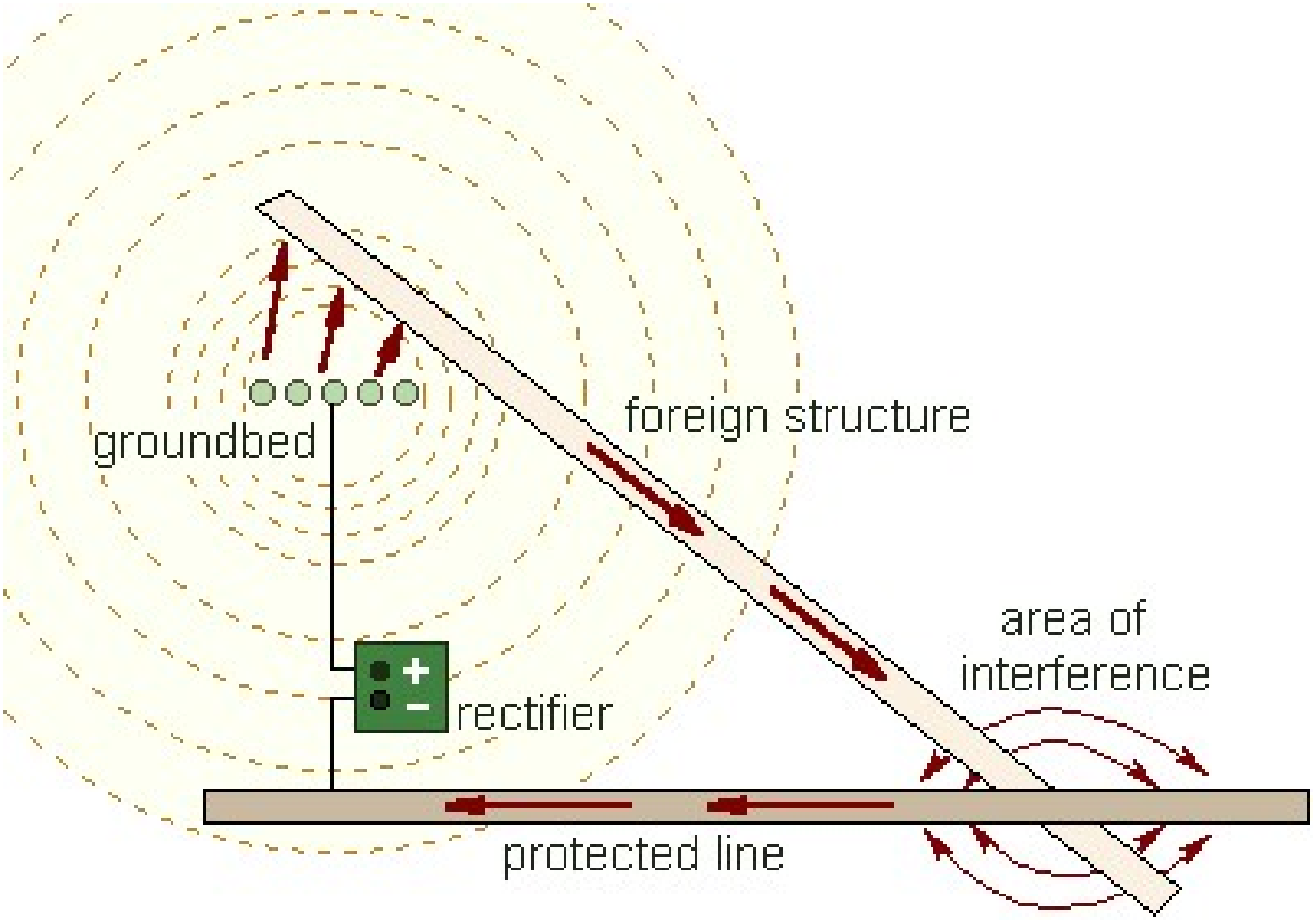
Each Calendar Year Not Exceeding 15 Months

Monitoring §192.465(b)&(c)

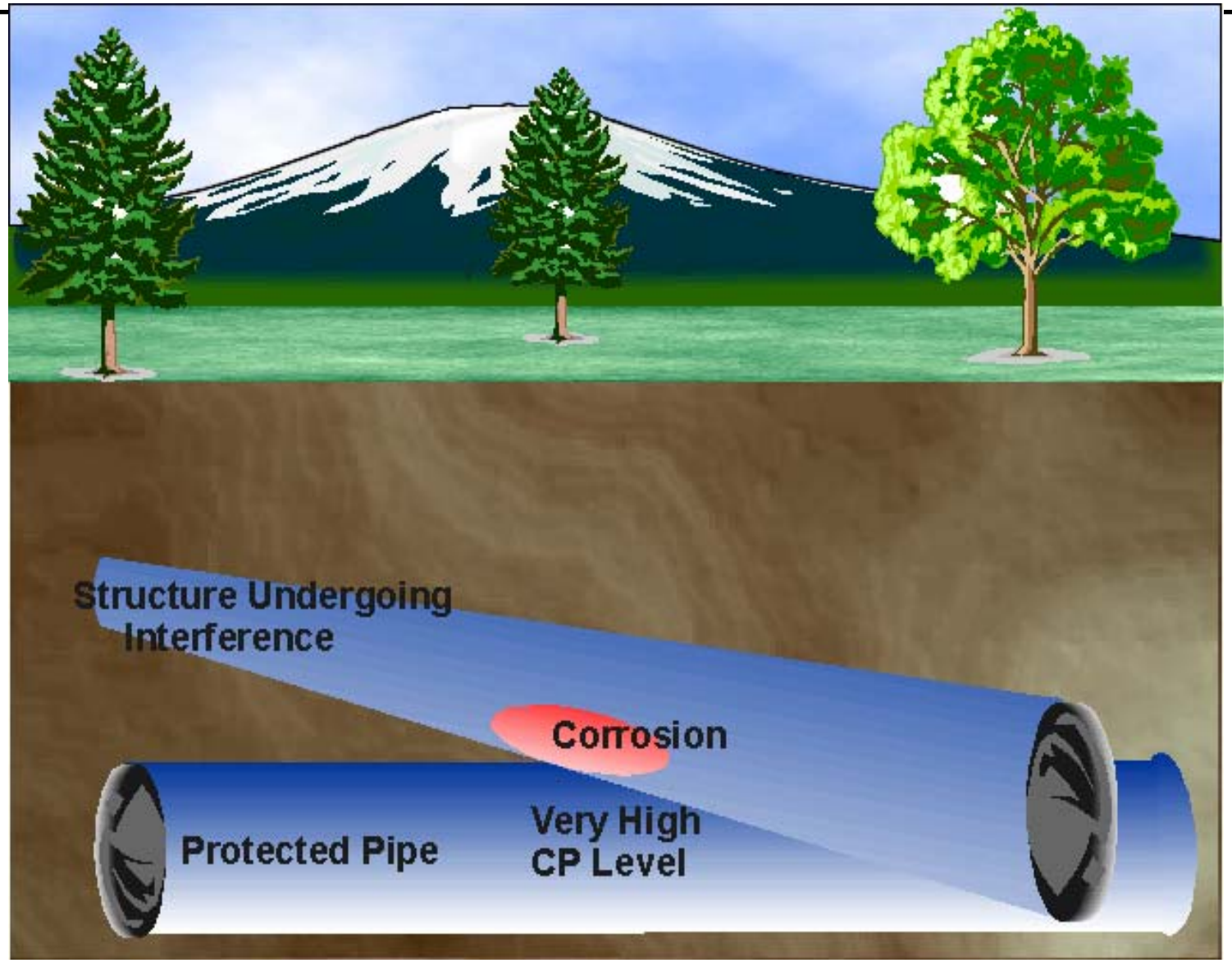
- Rectifiers
- Critical Bonds
- Reverse Current Switches
- Diodes

6 x year - Intervals Not Exceeding 2 1/2 Months

Monitoring §192.465(e)



Monitoring §192.465(e)



Monitoring §192.465(e)

- Reevaluation of Unprotected Lines
  - Every 3 Years not to exceed 39 Months
- Determine Areas of Active Corrosion
  - Electrical Survey (Where Practical)
  - Corrosion and Leak History
  - Leak Survey
  - Exposed Pipe Inspection Records
  - Pipeline Environment

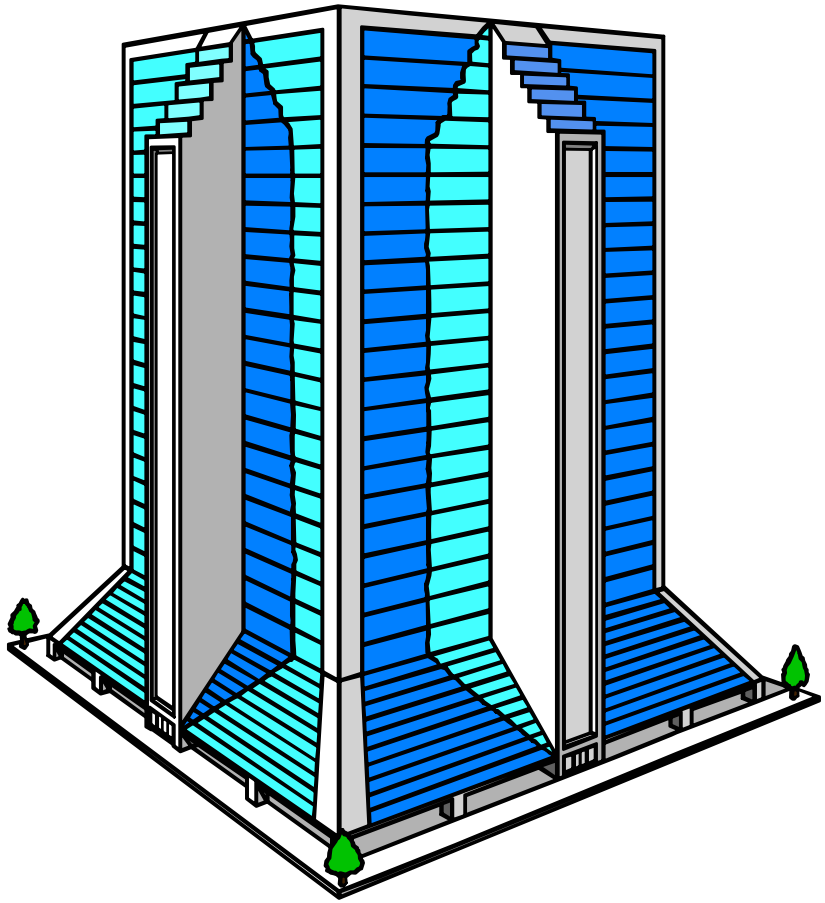
Active Corrosion

- **Continuing corrosion which, unless controlled, could result in a condition that is DETRIMENTAL to PUBLIC SAFETY -- §192.465(e)(1) [was 457(c)]**

Detrimental to Public Safety

Considerations

- Pipeline Location
  Population Density
  Road Crossings
- Pressures
- Corrosion Rate
  (3 Year Intervals)



Electrical Survey

- **Definition (Per §192.465 (e)(2))**

…A series of closely-spaced pipe-to-soil readings over a pipeline that are subsequently analyzed to identify locations where a corrosive current is leaving the pipeline

Electrical Surveys

What's Impractical

- Wall to Wall Paving
- Common Trench
- "Stray Current" Areas
- Pipeline Cover In and Out of Paving

Pipeline Environment

- Soil Resistivity (High or Low)
- Soil Moisture (Wet or Dry)
- Soil Contaminants
- Other Known Conditions

Monitoring §192.459

- **Examination of Pipelines When Exposed for Any Reason --**

- **Check Condition of Pipe and Coating**

Exposed Pipelines

- Investigate to determine whether corrosion or coating deterioration exists
- If corrosion found, investigate beyond exposed area (visual or other means)
- Repair any problems
- Keep records

§192.465(d) Remedial Actions

- "Within Monitoring Period"
- "Prompt"

Consider:

- Population Density
- Environmental Concerns
- Rate of Corrosion
- Climatic Conditions
- Availability of Materials

Electrical Isolation §192.467

- From Other Underground Structures
- From Casings
- Effective Insulation
- Protection From Arcing

Shorted Casings

- P/S reading **ESSENTIALLY** the Same as Casing reading

Other Tests May be Necessary to Demonstrate Isolation

Shorted Casings

Remedial Measures

- 1) Clear the Short
- 2) Fill Annular Space with Dielectric
- 3) If 1 or 2 Impractical, Monitor with Gas Detection Equipment at Intervals Specified in .705 & .721, or Smart Pig

Test Stations/Test Leads §192.469 & 471

- Must Have **SUFFICIENT** Test Stations or Other Contact Points to Determine the Adequacy of Protection.

Test Leads §192.471

- Attach to Minimize Stresses on Pipe
- Coat the Bared Wire/Pipe Connection
- Maintain Mechanically Secure & Electrically Conductive

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Internal Corrosion Control

§192.475

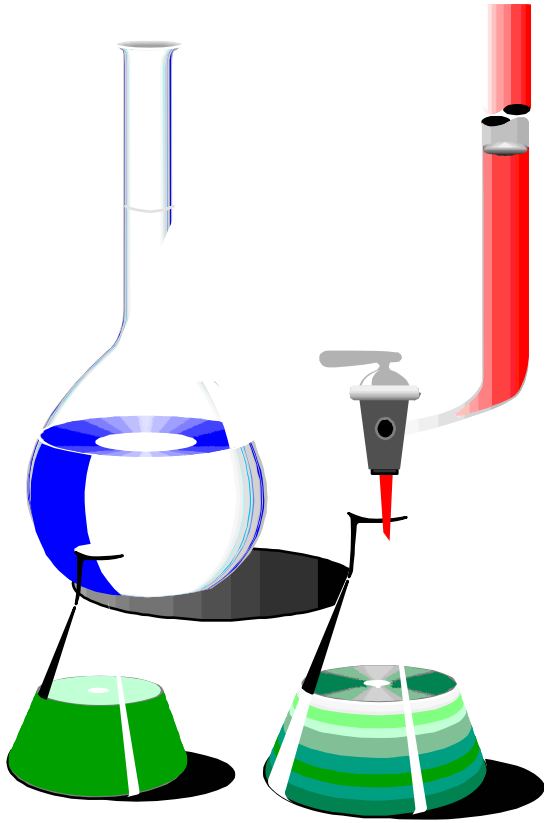
- Corrosive Product Transported
  - Test to Determine Effect on Pipeline
  - Take Steps to Minimize Effect
- Whenever a Segment is Removed
  - Inspect Internal Surfaces
  - Replace if Required By Remedial Measures

Internal Corrosion Control ~ Monitoring

§192.477

- **When Corrosive Product is Transported**
  - **Must Be Monitored For I.C.**
  - **2x Calendar Year N.T.E. 7 ½ mos.**

Coupons
Water Analysis
Microbiological Analysis
Inhibitors

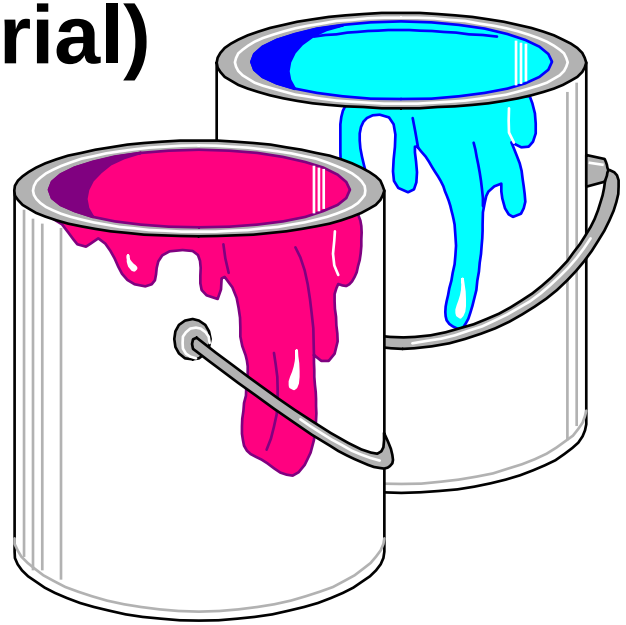


Atmospheric Corrosion Control

§192.479

- Pipeline Exposed to Atmosphere
  - Cleaned
  - Coated (Suitable Material)

Unless Non-Corrosive Environment or Only Light Surface Oxide



Atmospheric Corrosion Control §192.479

- **Non-Corrosive Environment not applicable to Offshore Splash Zones or Soil-to-Air Interfaces**

Atmospheric Corrosion Control Monitoring ~ §192.481

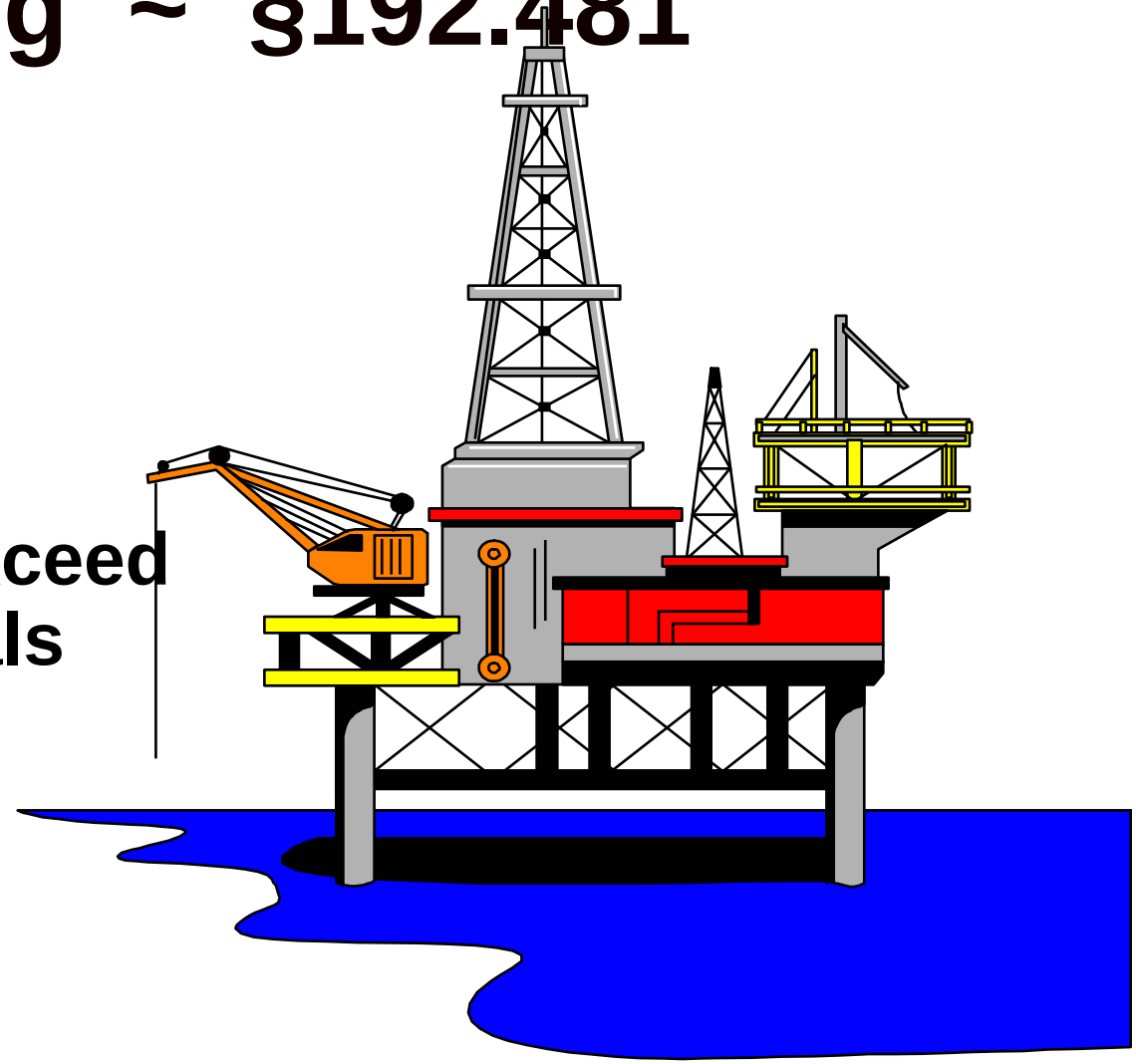
- **Onshore**

  Every 3 Calendar Years at Intervals not exceeding 39 Months

Atmospheric Corrosion Control Monitoring ~ §192.481

- **Offshore**

Every Calendar Year Not To Exceed 15 mos. Intervals



Atmospheric Corrosion Control

Monitoring ~ §192.481

Inspections Must Include Pipe:

- **At Soil-to-Air Interfaces**
- **Under Thermal Insulation**
- **Under Disbonded Coatings**
- **At Pipe Supports**
- **In Splash Zones**
- **At Deck Penetrations**
- **In Spans Over Water**

Remedial Measures ~ General

§192.483

- **Pipe that Replaces Pipe because of External Corrosion**

Cleaned
Coated
Cathodically Protected

Remedial Measures

Transmission §192.485

- General Corrosion
  - Replace
  - Lower MAOP/MOP
  - Repair

- Localized Corrosion
  - Replace
  - Repair
  - Reduce Operating Pressure

Remedial Measures

Transmission §192.485

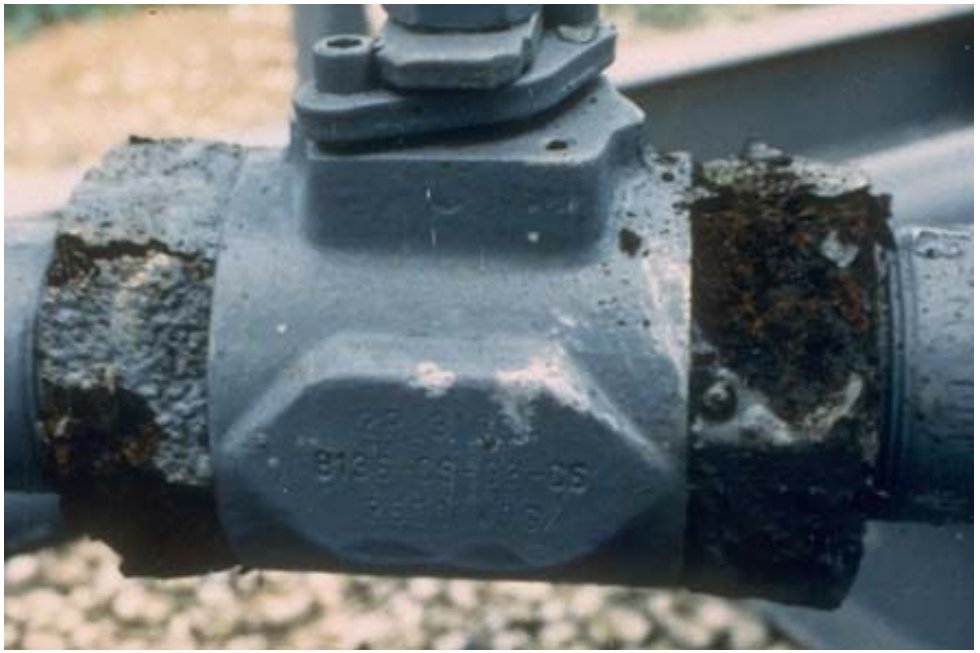
- General Corrosion
  - Closely Grouped Pitting Affecting Overall Strength of the Pipe
- Localized Corrosion Pitting

Guides: GPTC & RSTRENG

Remedial Measures

Gas Distribution (exc. Cl & Dl) §192.487

- General Corrosion or W.T. <30% Remaining
  - Replace
  - Repair
- Localized Corrosion
  - Repair
  - Replace



Remedial Measures (Gas)

Cast & Ductile Iron §192.489

- Graphitization General
  - If Fracture May Result - Replace
- Localized-If Leakage Might Result
  - Repair
  - Replace
  - Seal Internally

Corrosion Control Records

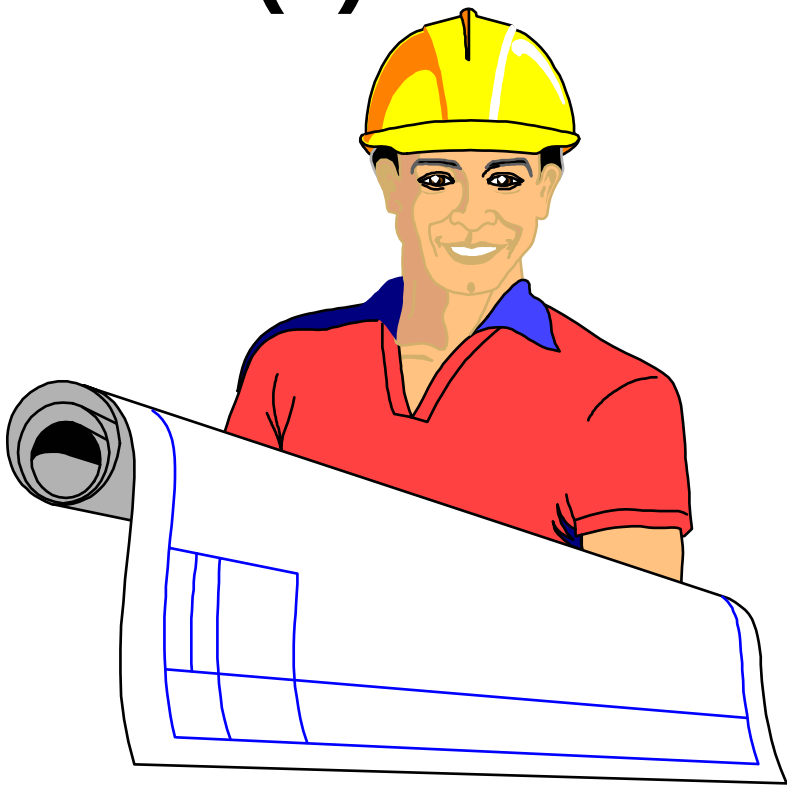
§192.491(a)

- Records or Maps
  - Location of Protected Piping
  - Cathodic Protection Facilities
  - Galvanic Anodes
  - Bonds to Other Structures

Corrosion Control Records

§192.491(b)

- Records or Maps Per 491(a)
  - Retain for Service Life of System



Corrosion Control Records

§192.491(c)

- Tests, Surveys, or Inspections
  - Required by Subpart I
  - Retain for at least 5 Years
  - Specified Exceptions
  - Check with Attorneys

Corrosion Control Records

§192.491(c)

- Exceptions/Retain for Service Life
  - Annual P/S Surveys ~ 465(a)
  - 3-Year Reevaluations ~ 465(e)
  - Inspections for Internal Corrosion ~ 475(b)